
Space Weather Technical Forecast

Issued on Thursday, 21 December 2023 at 13:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of isolated M-class flares throughout. CME from M-class flare being analysed.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with a M4.2 flare observed at 21/0538 UTC from AR3519 in the southwest quadrant. This was the only M-class flare over the last 24 hours, with a number of energetic C-class flares also observed. AR3521 in the north-centre disc and AR3529, the large, dominant, magnetically complex region in the southeast quadrant have been the main sources of this C-class flare activity. All these regions along with AR3528 have shown ongoing but limited evolution through the last 24 hours. These are the most notable of a total of nine regions on the visible disc, with the remaining regions either simple or inactive.

The M-class flare gave rise to a CME which has been analysed using STEREO data, as SOHO LASCO data was unavailable. Enlil output is being awaited to determine if there is an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar wind speeds have steadily declined from 500km/s to just below 400km/s as the Earth exits the high speed stream from coronal hole 82. Density is around average, also on a declining trend. Total magnetic field strength, Bt has been weak, with the north-south component, Bz varying weakly. Phi angle has been mainly positive (away from the Sun), with a brief incursion into the negative sector, early on 21 December. Total geomagnetic activity has been Quiet to Unsettled throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux has steadily increased from background to moderate levels, approaching high levels, reaching a peak of 9.09e3 pfu. 24-hour fluence started well below the Active threshold (1e8 integrated pfu) but reached 1.86e7 integrated pfu at 21/0000UTC.

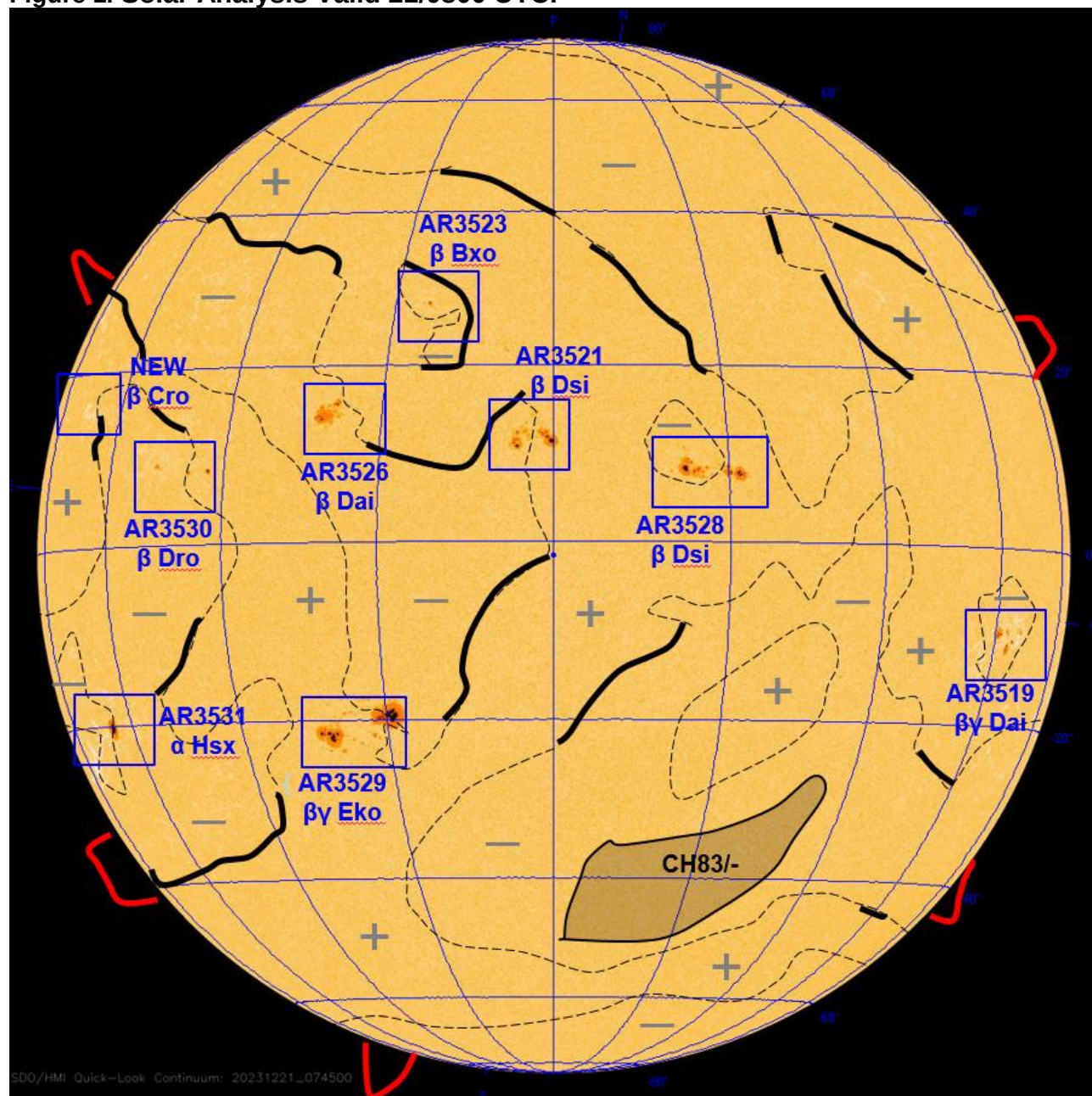
Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is expected, with a continued risk of M-class flaring, mainly from AR3519 and AR3529.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs are currently forecast. The high speed stream from coronal hole 82 is continuing to wane. A further high speed stream from coronal hole 83 is forecast to connect with the Earth either late on 21 December or during 22 December with speeds estimated at 550-650km/s. These are then likely to wane during 23 December. Geomagnetic activity is expected to remain largely Quiet to Unsettled during the period. There is a chance of Active and a slight chance of a G1/Minor Storm interval upon uncertain connection to a high speed stream on 21 December and more likely on 22 December.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is at Background levels and expected to remain at similar levels. High energy electron flux is expected to remain predominantly at moderate levels, with possible diurnal peaks at high levels through the period. Flux levels may reach more persistently high levels later in the period, but these are subject to uncertainties in the onset of the next high speed stream and possible effects on the radiation belts. Active electron fluence may approach the Active threshold, but is considered unlikely to reach Active levels in the forecast period.

Figure 1. Solar Analysis Valid 21/0800 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

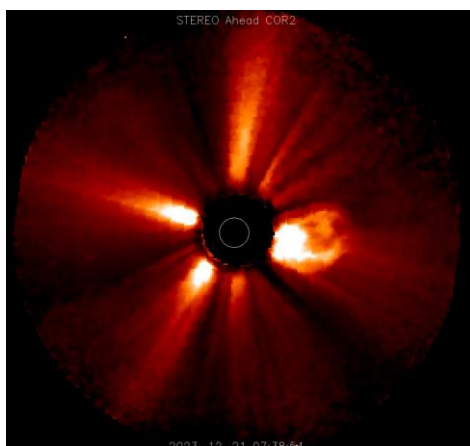
Geomagnetic Storms:

A CME has erupted from the vicinity of AR3519 following an M-class flare early on 21 December. This has been analysed and is currently being modelled for any potential Earth-directed component. A further eruption from close to AR3529 late on 20 December appears to have produced a weak southward directed CME which is not considered as a risk to Earth. Solar wind speeds are declining as the high speed stream from coronal hole 82 continues to wane. The high speed stream from coronal hole may then connect with the Earth either late on 21 December or during 22 December. Speeds may reach 550-650km/s based on persistence, although the signal on the last rotation may have been masked by multiple CMEs. Therefore, there is high uncertainty in the speed and any connection as the hole is to the south with any high speed stream potentially only glancing the Earth. As the Earth is also approaching the December solstice, any effects are likely to be limited. Winds are then likely to decrease from 23 December.

Geomagnetic activity should remain largely Quiet to Unsettled during the period. There is a chance of peak Active conditions and a slight chance of an isolated G1/Minor Storm interval should connection to the arrival of the high speed stream of CH83/- occur late 21 December or during 22 December.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: STEREO A imagery of CME following M4.2 flare at 21/0538 UTC.



Radio Blackouts - X-Ray Flares:

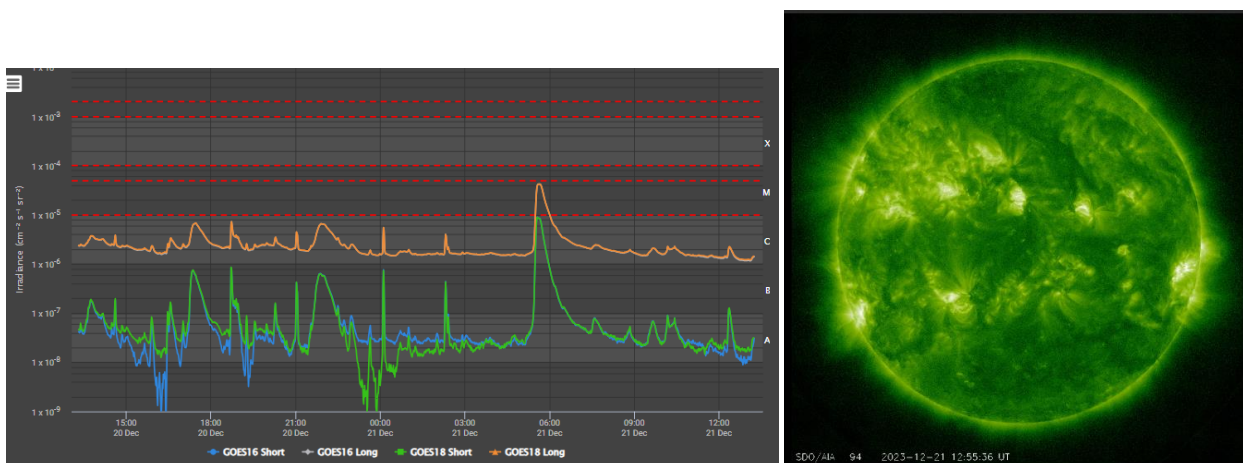
Solar activity is Moderate, with one M4.2 flare observed from AR3519. This is a magnetically complex region which is approaching the western limb and carries a continued risk of significant flare activity. AR3529 in the eastern hemisphere is the largest, most complex and dominant feature on the overall disc, but has appeared relatively stable. There is a line of three generally complex regions, AR3526, AR3521 and AR3528 in the northern hemisphere spanning the central meridian, all of which have not demonstrated significant activity or development, although further development is likely.

AR3519 is forecast to rotate across the western limb on 23 December, although there is a risk of flares being observed for a period after the region disappears from view, which means that elevated probabilities are maintained through to the end of the period.

The remaining regions all appear to be benign or declining with no new regions appearing or forecast to rotate into view through the forecast period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 X-ray flux for the last 24 hours and the SDO AIA-94 imagery of the M-class flare mentioned in the text.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is at normal background levels and expected to remain at similar levels in the absence of significant flare activity. The risk of minor solar radiation storms increases slightly as spots currently in the eastern hemisphere rotate into a more geo-effective position.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is at background to moderate levels on a steadily increasing trend on diurnal peaks. Peaks at high levels are possible on 21 and 22 December due to the recent but declining high speed stream. Further increases are subject to the possible connection to the next coronal hole high speed stream. However should this occur the onset could generate increased geomagnetic activity which may lead to a short suppression in flux levels. There is also a chance that much of the high speed stream may not connect with the Earth. Overall electron flux levels are forecast to be close to or slightly above the high threshold through the next four days.

Electron fluence values are showing a rising trend which is likely to slow with the shallower increases in electron flux forecast over the next four days. There is therefore a slight chance of reaching the Active threshold through the next four days, based on both the slower rate of increase in the flux and the uncertainty in the connection to the coronal hole high speed stream.

GEO Electron Environment	Level (cm ⁻² sr ⁻¹ day ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1x10 ⁸	No	5	10	10	10
Very Active	≥ 2 MeV ≥ 1x10 ⁹	No	1	1	1	1